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November 29, 2016

VIA E-MAIL AND REGULAR MAIL

James Morris, Esq.
Office of Regional Counsel
U.S. EPA - Region 5
77 West Jackson Boulevard
Chicago, IL 60604-3590

Re: AK Steel Corporation – Middletown Works
Docket No. CAA-05-2016-0030

Dear Jim:

Pursuant to Attachment A, Condition 3 of the above-referenced Consent Agreement and Final Order, enclosed is the *Emission Control System Evaluation and Computational Fluid Dynamic Modeling Report* prepared by SNC Lavalin America.

AK Steel agrees with SNC Lavalin's recommendations contained in Section 5.0 of the report. AK Steel is therefore not submitting additional recommendations.

Please let me know if you have any questions. AK Steel looks forward to U.S. EPA's response.

Sincerely,

FROST BROWN TODD LLC

Steven M. Wesloh

Steven M. Wesloh

SNC·LAVALIN	
	CLIENT: AK STEEL
	LOCATION: MIDDLETOWN, OHIO
	PROJECT: Coke Plant
	Emission Control System Evaluation and Computational Fluid Dynamic Modeling Report
	Project No: 640422

ISSUE/REVISION INDEX

No.	By	Reviewed	Date	Revision Details
0	Bakowski	Cross	Nov. 28, 2016	Final Report Issued

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1.0 EXECUTIVE SUMMARY

SNC Lavalin America (SLAI) was retained by AK Steel to perform an evaluation of their coke plant traveling hood emissions capture system to satisfy AK Steel's consent agreement with the US Environmental Protection Agency. The field evaluation included observations of the coke pushing operations, flow testing of the duct and general inspection of the emission control system. Computational Fluid Dynamic (CFD) Modeling was used to determine the capture efficiency during the coke pushing operations. CFD was also used to model modifications to the hood to determine the capture efficiency improvement.

Observations of the operations concluded that the capture system performs well when the coke is initially pushed from the furnace to the quench car. As the quench car moves towards the west to allow the filling of the car, emissions tend to drift out from beneath the hood and into the atmosphere.

Inspections of the equipment show that the baghouse, fans and plenums are in generally good repair with no cracks visible. The traveling hood and flexible belt, which runs on top of the main collection duct, was in generally good repair and operated without any noticeable issues.

Several CFD models were run to determine the best course of action to improve the capture efficiency. Some of the suggestions provide minimal increase to the capture efficiency while others provide significant increase to the capture efficiency. Furthermore, a few of the modeled scenarios actually decrease the capture efficiency of the hood.

The average capture efficiency of the hood ranges from 78% to 81% dependent upon the oven being pushed, car position and wind direction. Applying the recommendations detailed below, the capture efficiency can be expected to improve up to 25% by replacing the existing hood with a more efficient design.

This report outlines and details the site observations, CFD modeling procedure, and the model results with their respective capture efficiencies.

2.0 INTRODUCTION

SNC Lavalin America (SLAI) was retained by AK Steel to perform an evaluation of their coke plant traveling hood emission capture system in order to satisfy AK Steel's consent agreement with the US Environmental Protection Agency. The purpose of this evaluation is to determine the most appropriate design of the new traveling hood and provide a report which outlines improvements, recommendations and conclusions of the evaluation.

AK Steel operates a coke plant at its Middletown Works facility. The coke plant includes a 76 oven battery complete with larry car to fill the ovens, coke pusher, coal bunkers, door machine, quench car and emission control system. The focus of this evaluation is on the emission collection system. The emission control system consists of five (5) baghouse modules, each with its own induced draft fan capable of drafting approximately 40,000 acfm. The main collection duct runs parallel with the battery and is equipped with a traveling hood. Prior to the "pushing" of coke, the traveling hood is aligned with the oven door to insure capture of emissions. Once the hood is aligned, the coke oven door is removed and the coke is "pushed" from the oven into an awaiting quench car. During this period, emissions are generated as the coke falls into and strikes the quench car. As the coke is pushed from the oven, the quench car is moved at a slow pace to insure an even distribution of coke in the car. When all of the coke has been pushed from the oven, the car will sit beneath the hood for a short duration prior to moving to the quench tower.

This report summarizes the Computational Fluid Dynamic modeling analysis and provides recommendations to improve the overall capture efficiency of the emission control system.

3.0 SITE INVESTIGATION

Site visits were conducted to observe the coke battery operation, perform flow testing to determine the ventilation volume and to gather process and operational data.

3.1 FLOW TEST RESULTS

Flow testing was performed at various locations within the duct system during pushing operations as shown below.

Pushing Door	Test Location	Volume
No. 5	Across from Door No. 43	21,300 acfm
No. 3	Across from Door No. 43	24,300 acfm
No. 11	Across from Door No. 21	82,200 acfm (1)
No. 13	Across from Door No. 21	93,800 acfm

(1) = Possible anomaly during coke pushing

3.2 QUENCH CAR / TRAVELING HOOD

The quench car and traveling hood were observed during the pushing of coke. The quench car was found to be in good repair. When the coke is initially pushed from the oven, the hood does a fairly good job of containing and evacuating the emissions. Once the quench car starts to move, it was observed that emissions tend to escape the hood to the west and north. When the battery was idled, a closer inspection of the hood was performed. A baffle plate was noticed inside the hood, and a duct was noticed on top of the hood with an opening on the west side of the hood. The baffle plate does a good job of keeping the emissions contained during the initial pushing of coke. As the car moves, emissions from the quench car are still generated but are on the opposite side of the baffle plate. As a result, these emissions are not evacuated through the emission capture system. The duct on top of the hood, as seen in Figure 3-1, was designed to capture emissions which drift towards the west. As presented in the modeling results below, this design does not have enough draft capacity to evacuate all of the emissions as they drift beneath the hood.

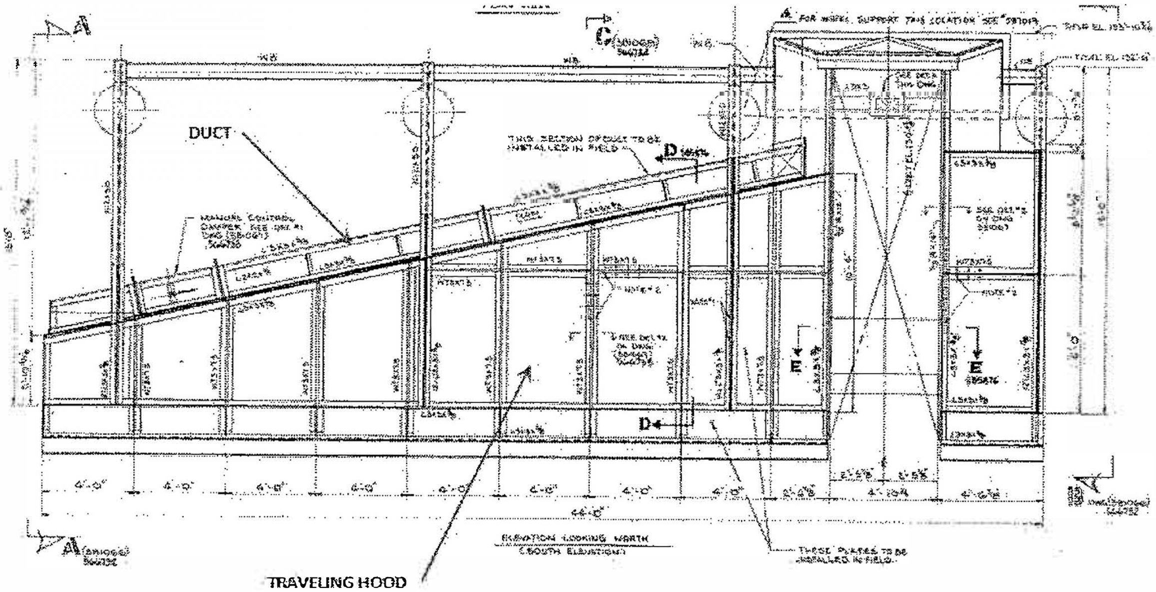

FIGURE 3-1 – TRAVELING HOOD

3.3 MAIN COLLECTION DUCT

The flexible belt which seals the top portion of the main collection duct was inspected and found to be in good repair. The flexible belt operates with the moveable hood to provide evacuation of the coke pushing emissions. The moveable hood, in turn, operates in conjunction with the coke guide to line up with the oven where the coke is about to be pushed. The flexible belt was fairly tight against the duct providing a good seal.

3.4 ID FANS

In addition to performing flow testing, stack test data was also examined to determine the flow through the system. Each fan is designed for 32,000 acfm at 20"wg static pressure. The fan curve is shown in Figure 3-2.

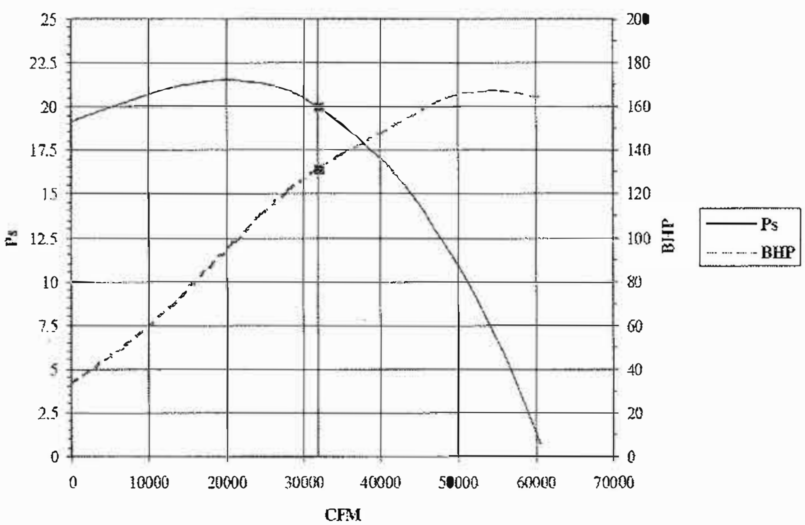

FIGURE 3-2 – COKE PUSHING BAGHOUSE FAN CURVE

Stack testing from late August through early September of 2016 shows that the average flow for three (3) fans running is approximately 130,600 acfm. This testing shows that the fans are performing above their design criteria.

3.5 BAGHOUSE / SPARK ARRESTOR

A cursory inspection of the baghouse and spark arrestor was conducted during the site visits. The baghouse and inlet plenum appear to be in good repair. No holes or visible damage was noticed. The spark arrestor also appeared to be in good repair as was the duct from the spark arrestor to the main collection duct at the coke battery.

4.0 CONCLUSIONS

1. The flow testing and stack test data shows that the ID fans are performing better than their design capabilities.

2. Various modifications to the hood were modeled using CFD to determine if the capture efficiency could be increased simply by modifying the existing hood. These modifications included:

   - Providing a better seal of the gap between the coke guide and hood;
   - Removing the interior baffle plate inside the hood to increase the draw from the west side of the hood;
   - Adding turning vanes in the upper portions of the hood to increase the draw to the west side of the hood;
   - Extending the sides of the existing hood to minimize the gap at the top of the quench car.

   The modeling showed that some of these suggestions certainly have their merits while others actually decrease the capture efficiency. A detailed explanation of results for each modification can be found in Section 7.0 and a table summarizing these results can be found in Section 8.0.

   In short, sealing the gap between the coke guide and the hood provided a minimal increase in capture efficiency. Removing the interior baffle and adding turning vanes actually decreased the capture efficiency of the hood. Of all the options considered to modify the existing hood, minimizing the gap at the top of the quench car provides the most significant increase in capture efficiency.

3. In addition to examining methods to modify the existing hood, a new hood was designed and modeled. The results show that the new hood provides higher capture efficiency than modifying the existing hood. The results of this model run are presented in Section 7.0.

5.0 RECOMMENDATIONS

1. Although the capture improvement is minimal, SLAI recommends closing the gap between the coke guide and hood. This can be achieved through the use of stainless steel brushes such as those manufactured by Sealeze. These brushes will flex when in contact with the hood. They will not break or damage the hood and still provide a seal around the coke guide and hood.

2. As shown with the CFD modeling, the existing hood can either be modified or replaced. Modifying the hood to minimize the gap between the hood and the quench car increases the average capture efficiency approximately 22% while replacing the hood increases the average capture efficiency to 26%. In order to achieve the most significant increase in capture efficiency, SNC Lavalin recommends replacing the existing hood. The approximate weight of the new hood is 30,000 lbs. The fabrication cost for this hood is approximately $225,000. The installation cost for this hood is approximately $160,000 making the total cost approximately $385,000. If additional services are included, such as third party engineering and internal project management, the cost for the new hood would be approximately $415,000.

6.0 COMPUTATIONAL FLUID DYNAMIC MODELING METHODOLOGY

6.1 INTRODUCTION TO CFD MODELING

Computational Fluid Dynamic (CFD) Modeling is the science of predicting fluid flow and heat and mass transfer. CFD models are used to simulate flow conditions for a variety of applications by numerically solving coupled balance equations for mass (Conservation Equation), flow (Navier-Stokes Equation of Motion) and heat (heat transfer equations). The numerical approach taken by CFD is to break a given geometry (in this case, the geometry of the system surrounding and including the coke battery) into many smaller, geometrically simple pieces or elements. The equations can then be solved for each element with each element communicating with its neighboring element. The individual solutions for each element are then combined to give a solution for the overall volume (or domain).

6.2 MODEL GEOMETRY

The first step in developing this CFD model is to set up the geometry to describe the physical boundaries and internal blockages to fluid flow. The geometry of the model includes the physical bounds of the surrounding area which includes the coke battery, traveling hood, door machine, coke guide, quench car, baghouse and associated ductwork, combustion stack and quench tower. The baghouse, combustion stack and quench tower were included to determine the impact of the wind on various oven doors. These features tend to shield certain oven doors from wind from the north. Figures 6-1 through 6-4 represent the geometry for the models run for this project.

Figure 6-1 illustrates the surrounding air volume assigned for these model runs. The octagon shape was used to simulate air from any direction. The boundary of the octagon is approximately 150' away from the battery and/or quench tower.

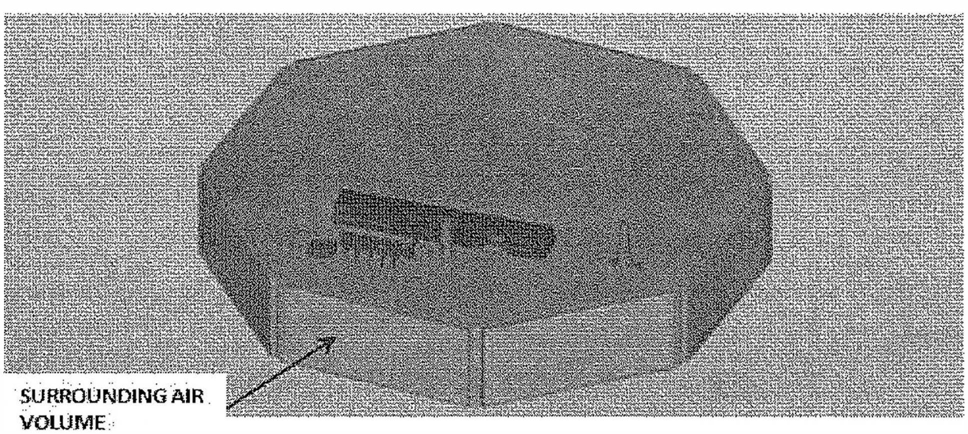

FIGURE 6-1 - GEOMETRY

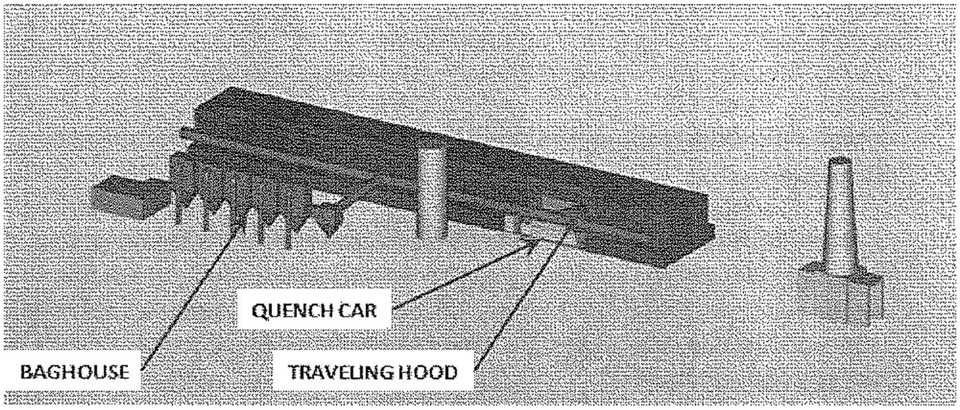

FIGURE 6-2 - GEOMETRY

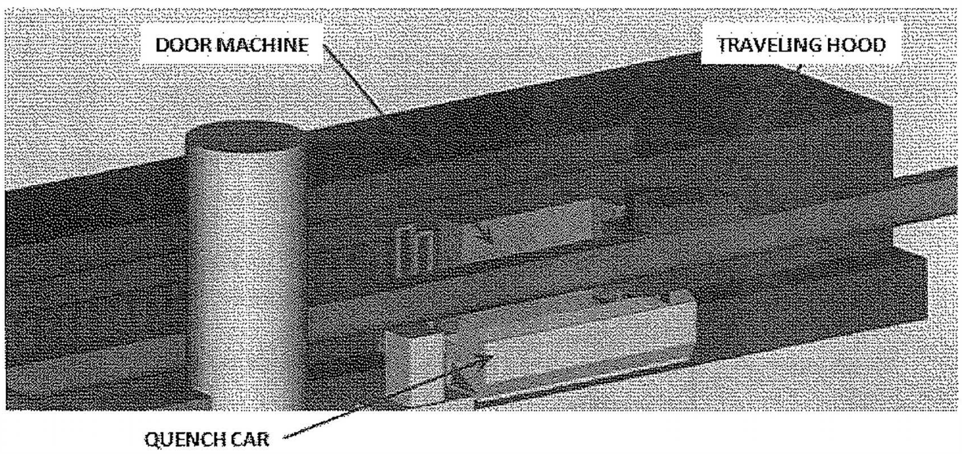

FIGURE 6-3 - GEOMETRY

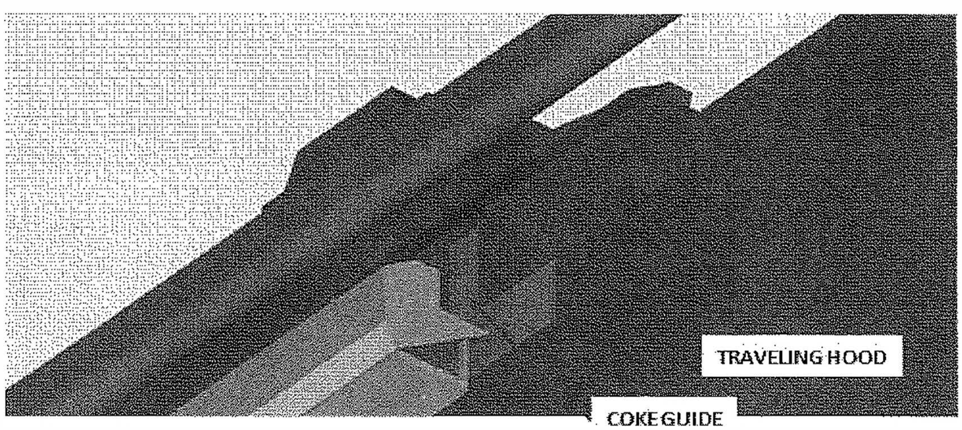

FIGURE 6-4 - GEOMETRY

6.3 MODELING METHOD

The current coke pushing operations were modeled using the existing conditions to provide a "base case" model for comparison with any proposed modifications and to qualitatively validate the model results against the video and photos recorded during our site visits.

All modeling is at steady state operations as opposed to transient conditions. With the steady state model, we are looking at the worst possible conditions during the pushing of coke and using those conditions as boundary conditions in the model. The corresponding capture efficiency is then calculated for the worst case condition rather than average conditions.

6.4 BOUNDARY CONDITIONS

The CFD model requires boundary conditions, that is, a starting set of conditions, such as ventilation volume, cross winds and temperature of the coke.

For the "base case" analysis, a wind speed of 8 mph is used in the model. Wind Rose data for Cincinnati/Covington and Dayton was obtained as well as data from the Southwest Ohio Air Quality Agency. Winds from the north, northwest and east are considered for the model. Winds from the southern directions are not considered because the coke pushing operations are on the north side of the battery.

An ambient air temperature of 70 deg F is assumed for all models.

In order to model the coke pushing operations, coke is represented both in the quench car and falling from the oven as it is pushed. The temperature assigned to the coke at these locations is 2000 deg F.

During the pushing of coke, the oven door is removed and the coke is pushed from the oven. At this time, the oven is under a slight positive pressure and was assigned a value of 0.4"wg. Additionally, the coke oven walls are assigned a temperature of 2000 deg F.

The ventilation volume of each exhaust fan is 40,000 acfm. Four (4) fans were assumed to be "running" for the modeling.

6.5 MESH

The CFD modelling software breaks down the complex geometry of the coke oven battery system into smaller pieces, typically referred to as the mesh or grid. Here, the calculations are performed to solve the equations for velocity, temperature, pressure, etc. Figure 6-5 illustrates the typical mesh for the models.

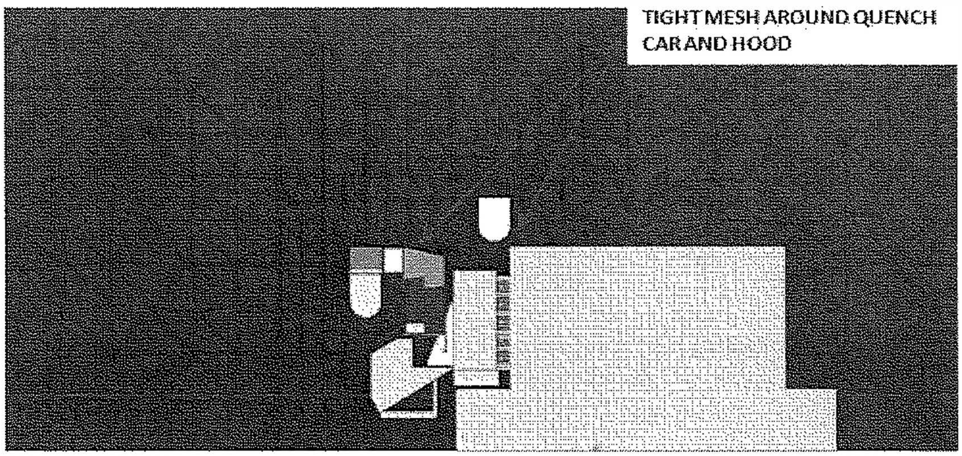

FIGURE 6-5 – TYPICAL MESH

6.6 TURBULENCE

The turbulence models used for all AK Middletown models are eddy viscosity and k-epsilon. The models are started with the eddy viscosity turbulence model, which is less computationally intense than the k-epsilon model, but is numerically very stable. Given the complexities of the coke oven battery system solution, the eddy viscosity turbulence model is used to develop the fluid flow towards solution. Once an appropriate number of iterations are run (model dependent), the turbulence model is switched to k-epsilon. This model is much more computationally intense than the eddy viscosity model and provides a more accurate solution.

6.7 CAPTURE EFFICIENCY

The capture efficiency is calculated by inserting particles of various sizes into the model at the area of interest, for example, on the surface of the coke in the quench car. The model calculates their path based on thermal currents, influence from the emission control system and cross winds from the outside. Once the model calculates each trajectory, a count is performed to determine the amount of particles captured in the duct. This number is subtracted from the total number of particles inserted into the model to obtain the capture efficiency.

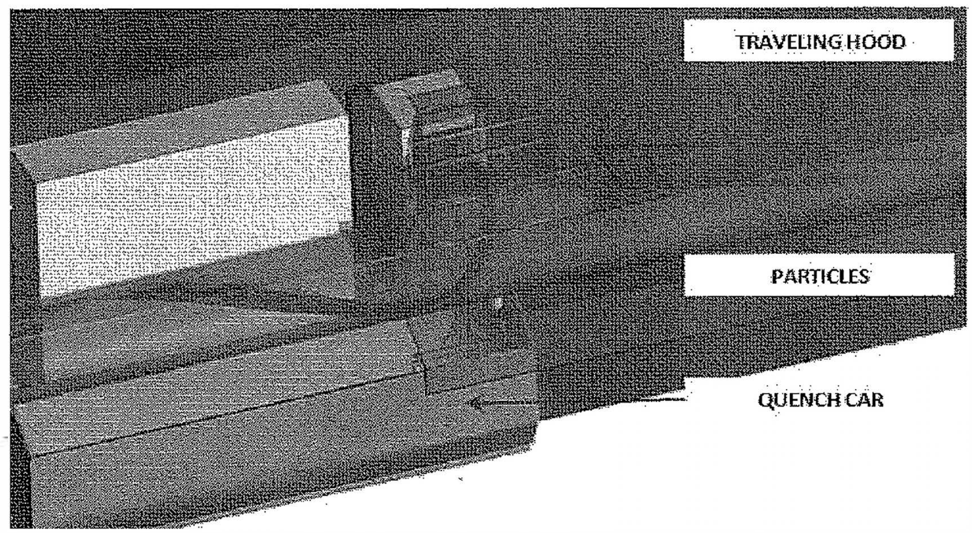

FIGURE 6-6 – EXAMPLE PARTICLE TRACE (SOME ITEMS REMOVED FOR CLARITY)

The particle size distribution (the percent of each particle that makes up the sample) is based on data published by the US EPA for Coke Production.

Particle Size:	15.0	10.0	5.0	2.5	2.0	1.0	0.5
Cumulative Mass:	50%	43.3%	26.6%	16.7%	14.8%	7.7%	3.1%

The data illustrates that particles less than 15 micron and below account for approximately 50% of the cumulative mass. The capture efficiency is determined by using the following particle sizes (microns):

0.5, 1.0, 2.0, 2.5, 5.0, 10.0, 15.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0

Particles 20 micron and above were extrapolated by extending the curve.

The capture efficiency is calculated as follows. Looking at the chart, we see that 1.0 micron size particles and smaller account for approximately 7.7% of the distribution. We also see that 0.5 micron particles account for approximately 3.1% of the total particles. By subtraction, we see those particles between 0.5 and 1.0 micron account for 4.6% of the total number of particles. The total mass percentage for each particle is then calculated using the above data.

The mass percentage for each particle is then weighed against the number of particles captured in the hood or escaping to the atmosphere. In the partial example below, Table 6-1 illustrates how the mass percentage is used to determine an overall capture efficiency.

TABLE 6-1 – EXAMPLE CAPTURE EFFICIENCY CALCULATION

Particle Size	Hood Capture	Mass Percentage	Weighted Average
0.5	100%	3.1	1 x 3.1 = 3.1
1	90%	7.7-3.1 = 4.6%	0.9 x 4.6 = 4.14
2.0	80%	14.8-7.7 = 7.1%	0.8 x 7.1 = 5.68
2.5	60%	16.7-14.8 = 1.0%	0.6 x 1 = 0.6
5.0	60%	26.6-16.7 = 9.9%	0.6 x 9.9 = 5.94
Continues up to 100 microns			

When all of the particle traces are calculated, the Weighted Average is then summed to provide the overall capture efficiency.

6.8 MODEL CONFIRMATION

Flow measurements and temperatures were recorded at various locations within the duct to confirm model accuracy. During the flow testing, a temperature of 155 deg F was recorded in the duct. As seen in Figure 6-7, the model is predicting approximately the same temperature.

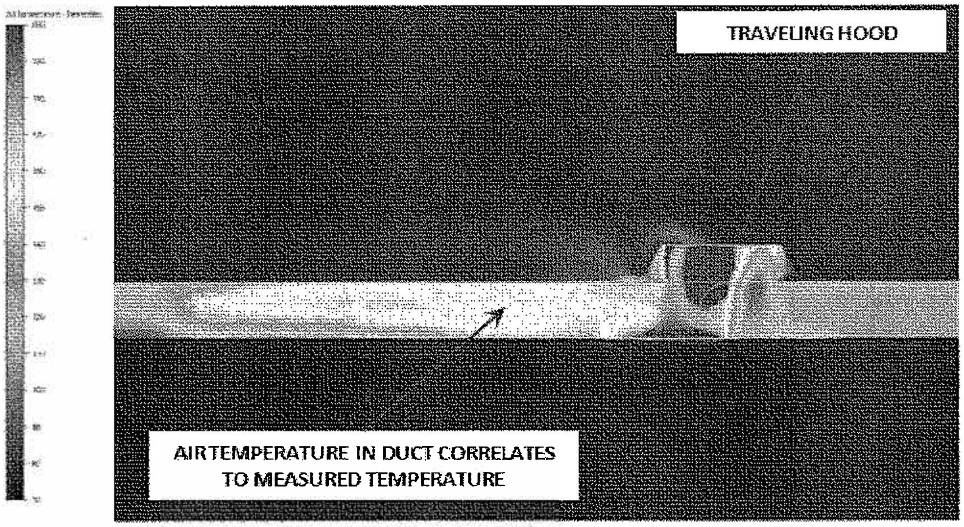

FIGURE 6-7 – DUCT TEMPERATURE (SOME ITEMS NOT SHOWN FOR CLARITY)

Additionally, the average temperature at the baghouse inlet is 130 deg F. As seen in Figure 6-8 below, the model is predicting approximately the same temperature. These figures confirm the accuracy of the model inputs for flow and temperature

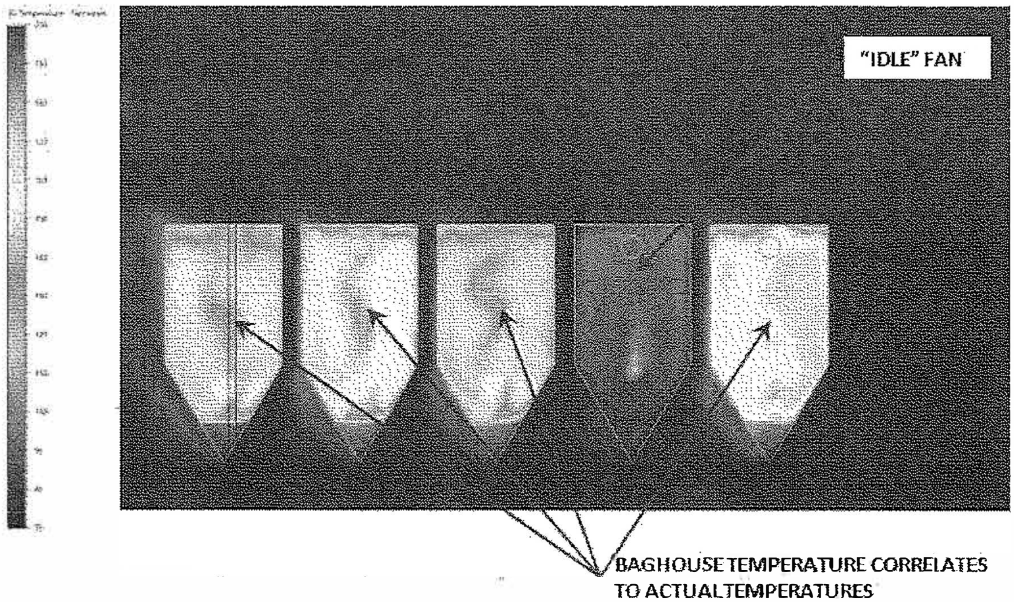

FIGURE 6-8 – BAGHOUSE INLET TEMPERATURE (SOME ITEMS NOT SHOWN FOR CLARITY)

7.0 COMPUTATIONAL FLUID DYNAMIC MODEL RESULTS

The coke pushing operations were examined through both visual observations and through Computational Fluid Dynamic modeling. Observations noted that the capture efficiency decreased as the quench car moved further west. This was represented in the model by positioning the quench car at three different locations beneath the hood. The first position, shown in Figure 7-1, shows the car in the first stages of the push. Figures 7-2 and 7-3 illustrate the position of the car as the pushing progresses.

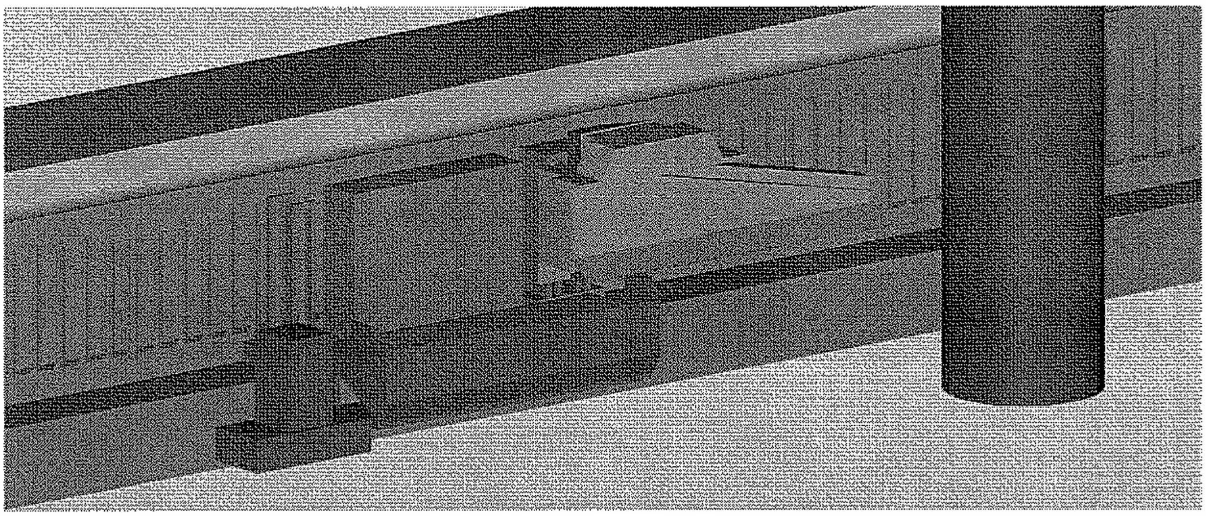

FIGURE 7-1 – FIRST POSITION

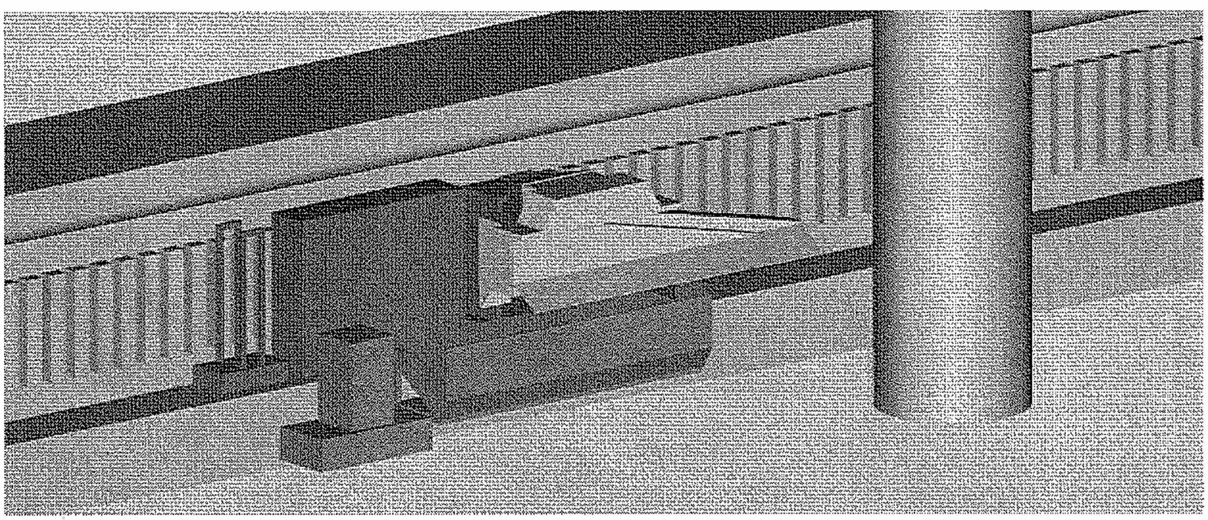

FIGURE 7-2 – SECOND POSITION

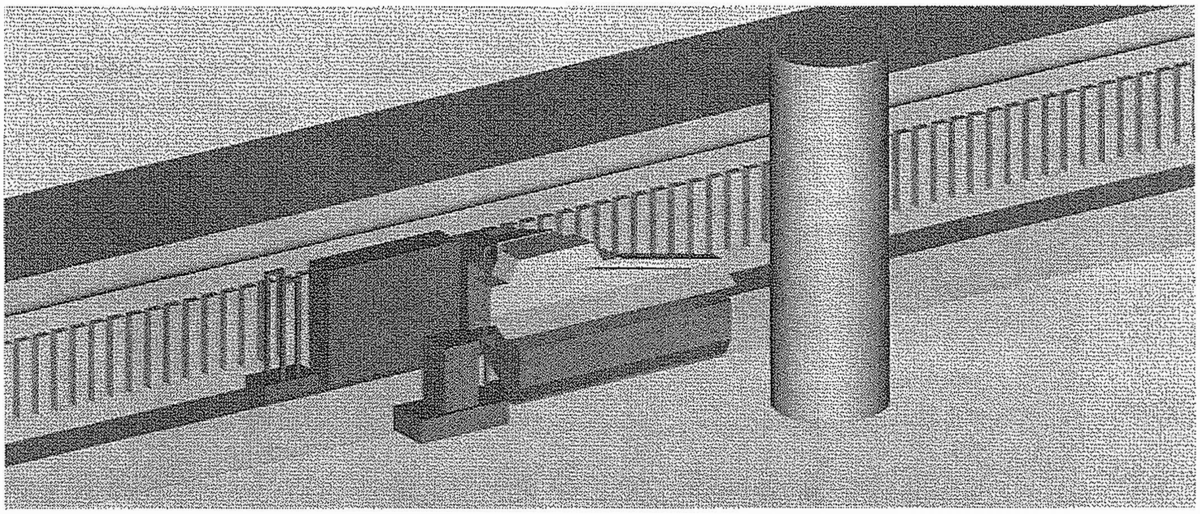

FIGURE 7-3 – THIRD POSITION

In addition to modeling various positions of the quench car, two oven door locations were modeled. The first location was at Oven Door No. 40 (approximately the center of the battery) and Oven Door No. 1 (the west most door).

Sections 7-1 through 7-3 illustrate the base case models. The purpose of the base case model, that is, the modeling of the existing conditions, is to duplicate as closely as possible the modeled results with the field observations. Once the base case models were finalized, additional models were developed. These models included proposed modifications such as modifying the hood, sealing the gap between the coke guide and hood and completely redesigning the hood.

7.1 EXISTING CONDITIONS – CAR POSITION No. 1

This model run simulates the coke as it is initially pushed from the oven into the awaiting quench car. Photo 7-1 shows this operation. As seen in the photo, the hood performs well as no emissions are seen escaping the hood.

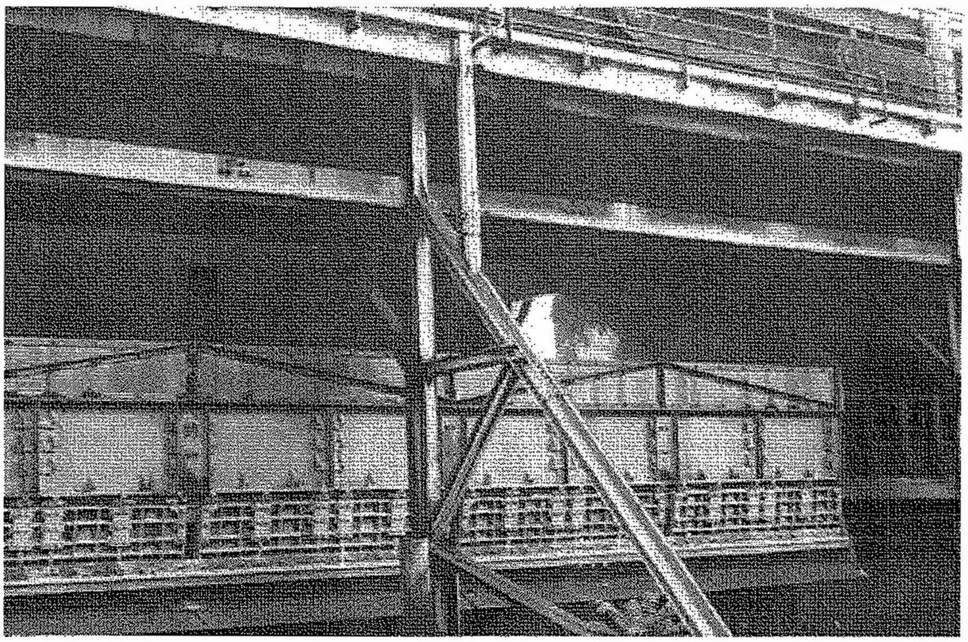

PHOTO 7-1 – COKE PUSHING

Figure 7-4 is a 3D representation of a 10 micron particle. As seen, the existing hood performs well by containing the emissions providing the emission control system time to evacuate the hood.

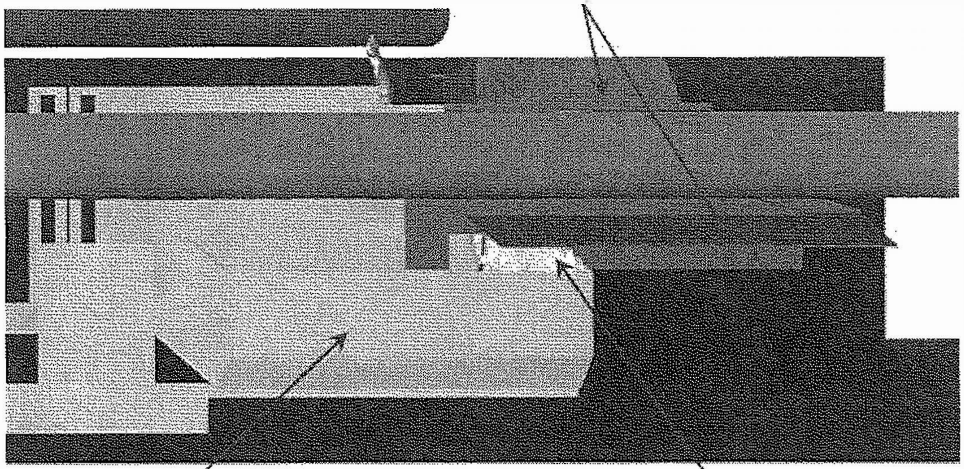

FIGURE 7-4 – COKE PUSHING MODEL RESULTS

As seen in the above photograph and figure, the hood performs well providing high capture efficiency in this position.

7.2 EXISTING CONDITIONS – CAR POSITION No. 2

This model run simulates the pushing operation as the car gradually begins to move towards the west. The quench car is represented at approximately 2/3 coverage beneath the hood. As seen in Photo 7-2 below, emissions begin to escape the hood as the car moves towards the west.

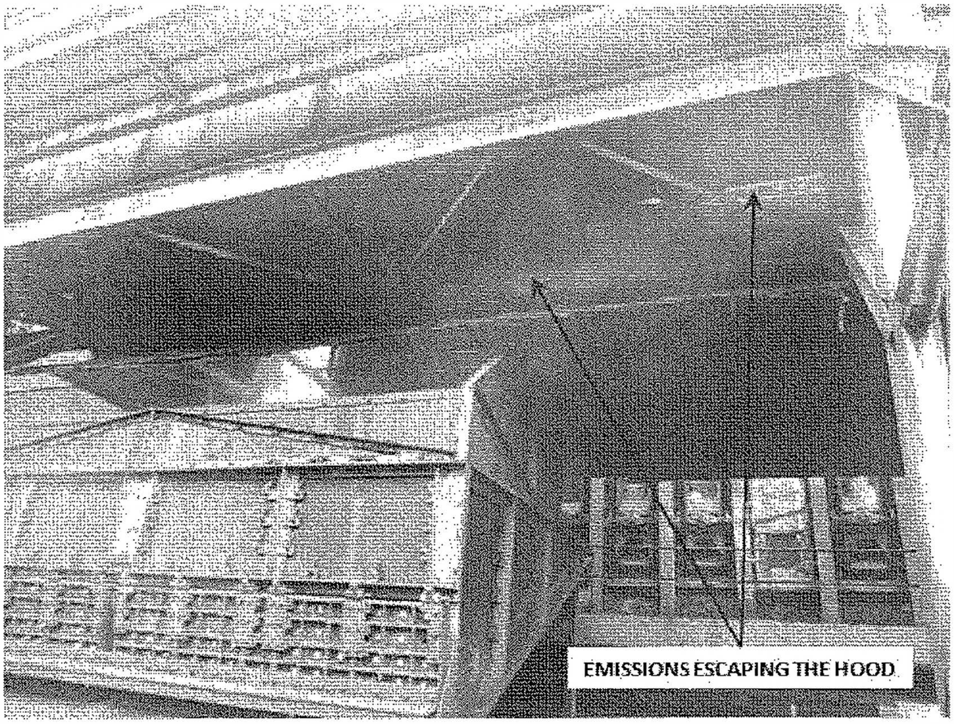

PHOTO 7-2 – COKE PUSHING

Figure 7-5 is a 3D representation of a 10 micron particle. As seen below, emissions are predicted to escape to the north and west. This is confirmed in the above photograph.

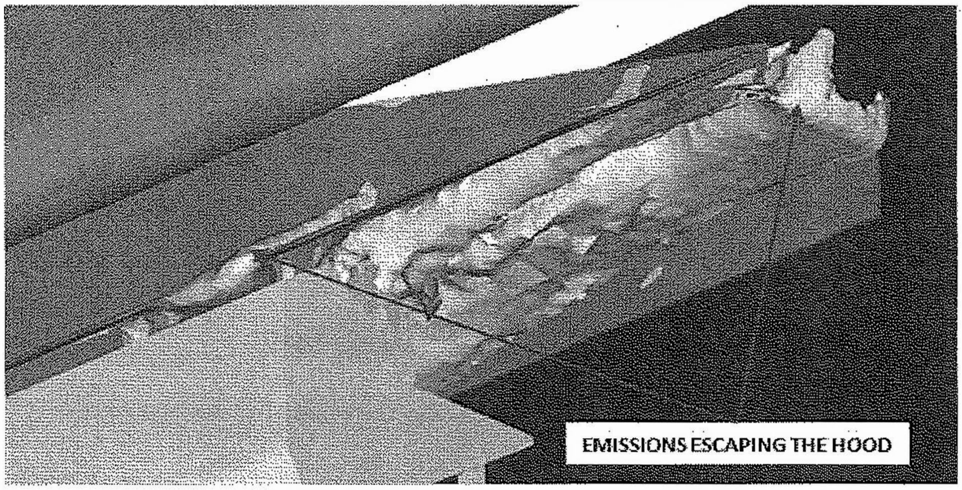

FIGURE 7-5 – COKE PUSHING – 3D REPRESENTATION OF 10 MICRON PARTICLES

7.3 EXISTING CONDITIONS – CAR POSITION No. 3

This model run simulates the pushing operation as the coke is nearly completely pushed from the oven and the quench car is nearly completely beneath the hood. Photo 7-3 shows this operation. As seen in the photo, emissions are escaping from beneath the hood.

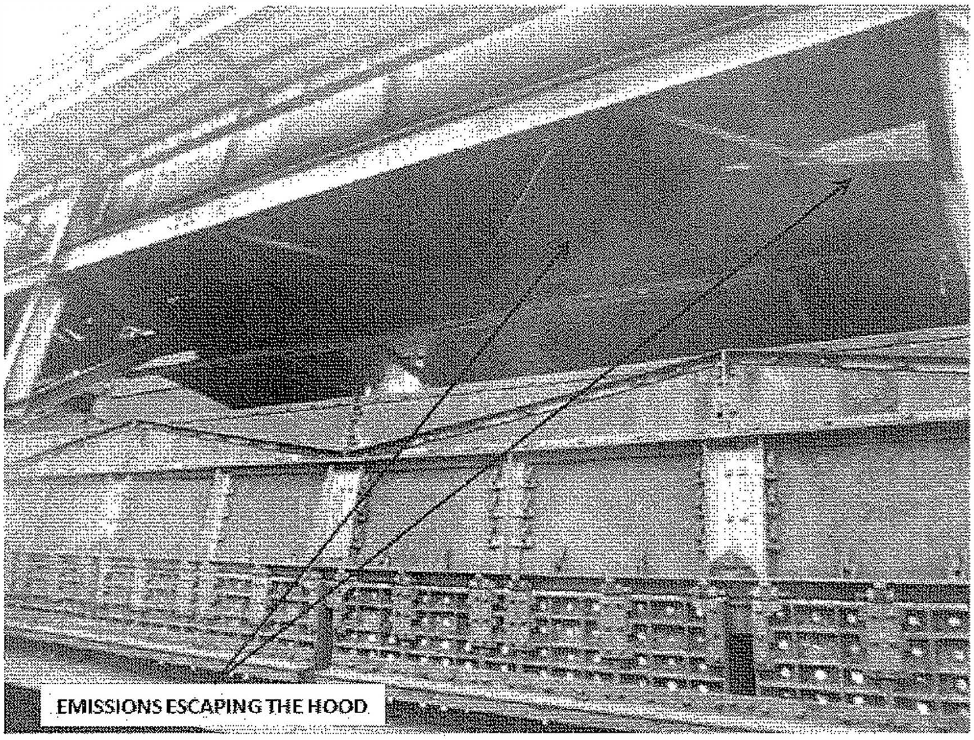

PHOTO 7-3 – COKE PUSHING

Figure 7-6 below is a 3D representation of a 10 micron particle. As seen below, the model is accurately predicting the path of the emissions.

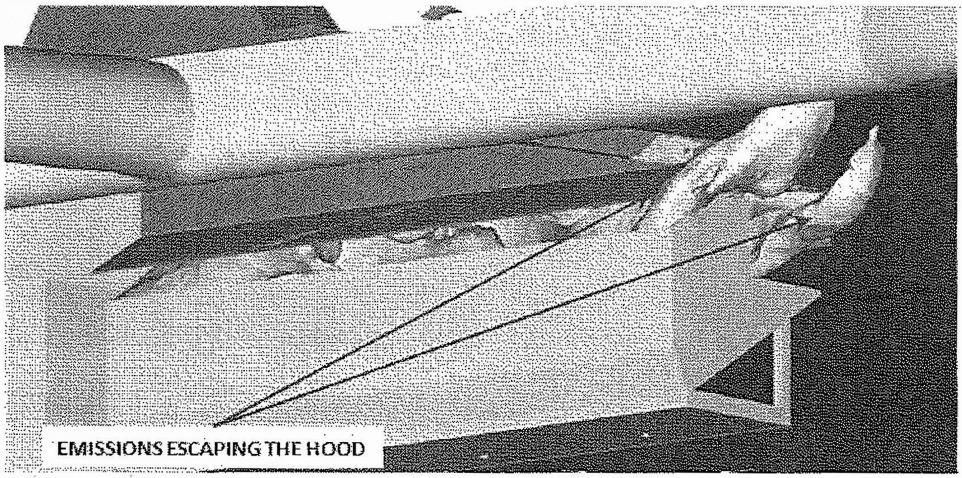

FIGURE 7-6 – COKE PUSHING – 3D REPRESENTATION OF 10 MICRON PARTICLES

Sections 7.1 through 7.3 represent a portion of the base case model runs for the coke battery. A complete list of model runs and associated capture efficiencies can be found in Section 8.0 below. As stated above, the purpose of the base case models is to develop confidence that the variables used as input accurately reflect conditions seen in the field. With the assurance that the base case models are accurate, the geometry is then modified to include/remove various features to determine which features improve the capture efficiency. In all cases, the model inputs remain constant. Sections 7.4 through 7.8 below describe the various hood configurations and compares the results to the base case models above.

7.4 SEAL GAP BETWEEN COKE GUIDE AND HOOD – CAR POSITION No. 1

Currently, the gap between the coke guide and hood is approximately 12" in length. Photo 7-4 below shows this gap. Although the majority of emissions escape from beneath the hood, sealing this gap would reduce the amount of excess air being drawn into the hood resulting in increased capture efficiency.

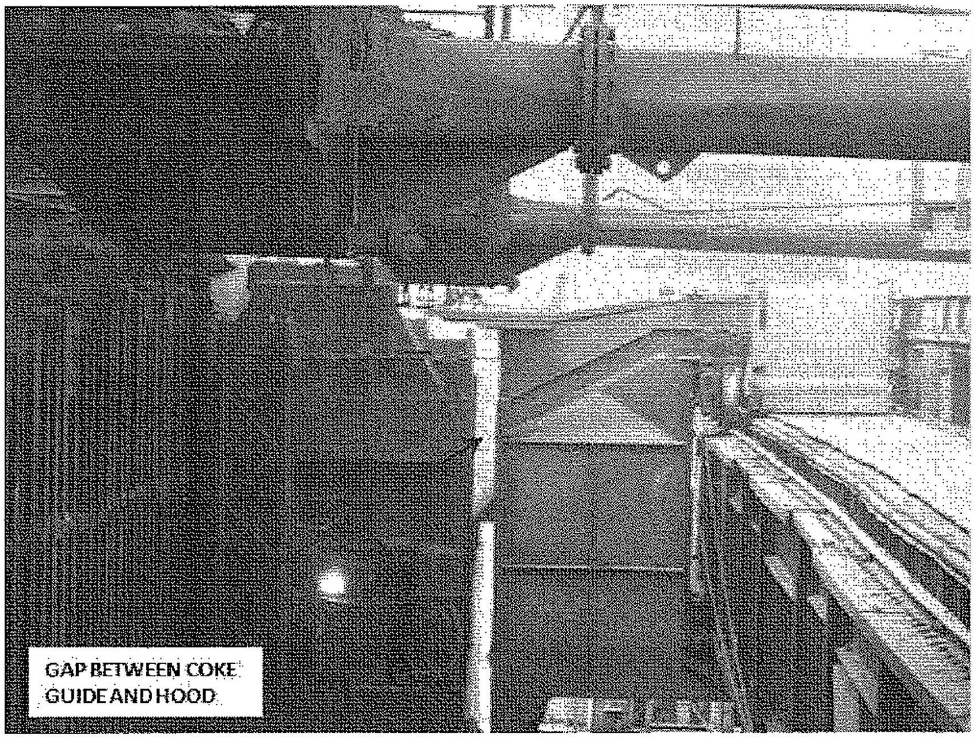

PHOTO 7-4 – COKE GUIDE AND HOOD (LOOKING WEST)

The gap was closed within the model as shown below in Figure 7-7 below. A series of brushes were assumed to be added around either the hood or coke guide. These brushes would flex as the hood moved along the length of the battery.

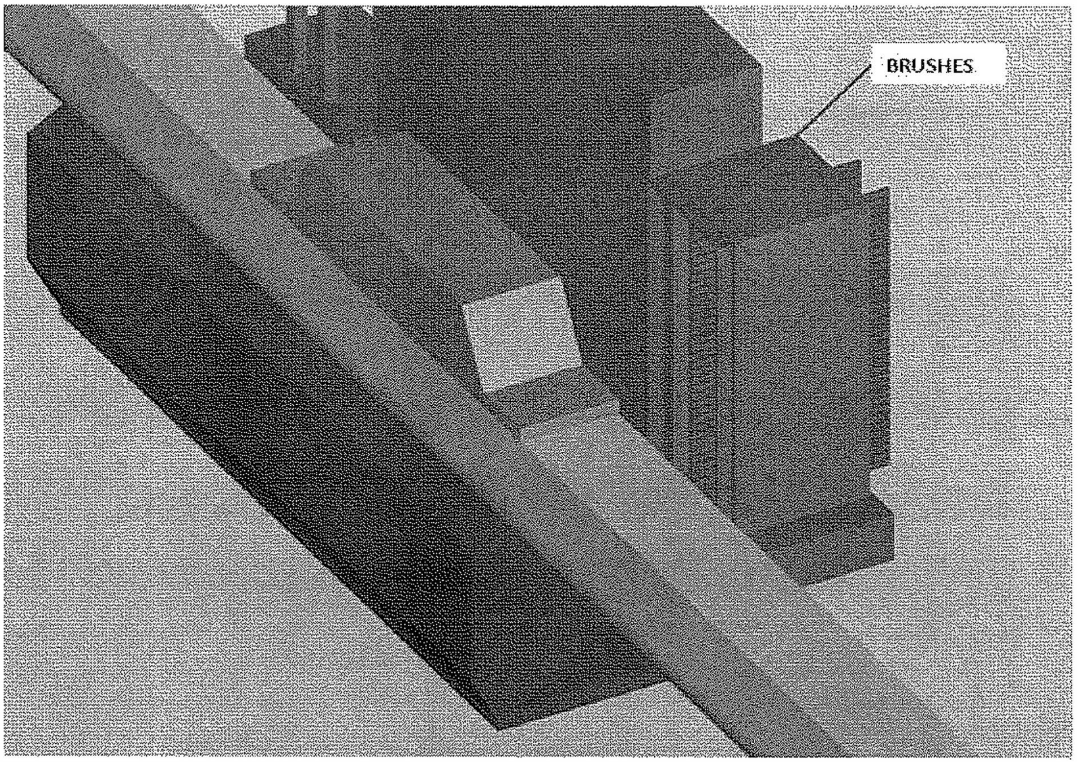

FIGURE 7-7 – BRUSHES AROUND COKE GUIDE

The model was run and the results indicate that a minimal increase in capture efficiency would be achieved. The brushes were represented as a resistance type element with a free area ratio of 50%. This ratio may be a little conservative, but the model does demonstrate the effectiveness of sealing this gap. The free area ratio (that is, the ratio of the open area to the entire area) may be smaller with the actual product selected therefore producing more beneficial results.

7.5 BAFFLE PLATE REMOVED – CAR POSITION No. 2

A baffle plate exists in the interior of the hood. This plate was observed to keep the emissions contained in a certain area inside the hood providing time for the system to evacuate the emissions. It was also observed that emissions which migrate on the opposite side of the plate are not drawn into the emission control system and escape the hood entirely. A model was created with the quench car approximately 2/3 beneath the hood and the interior baffle removed. Photo 7-5 shows this interior baffle.

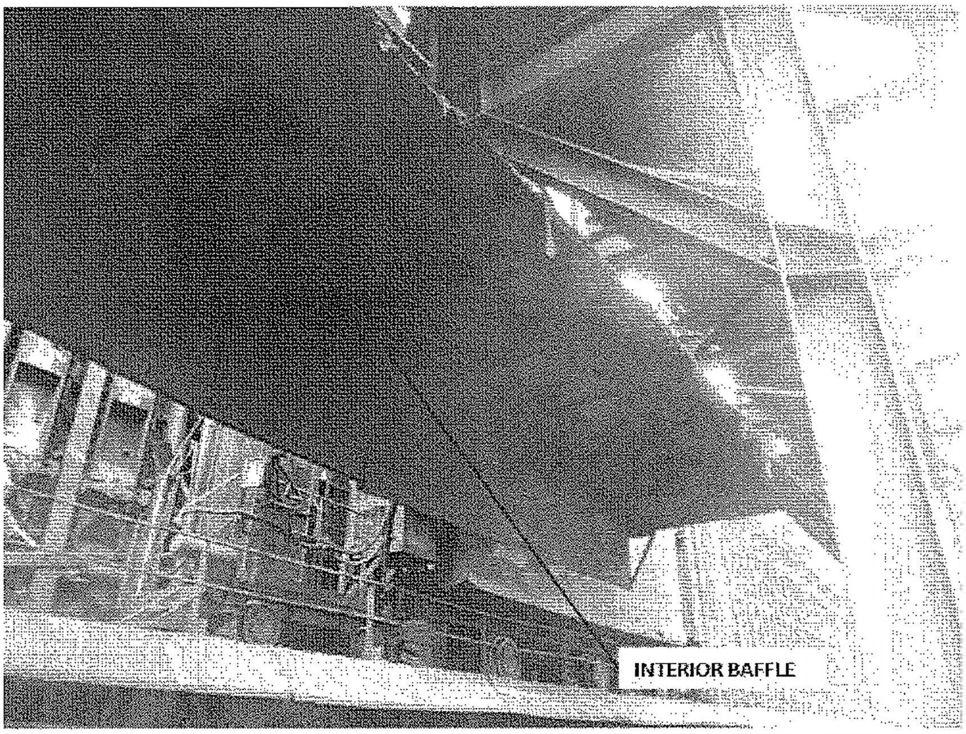

PHOTO 7-5 – TRAVELING HOOD

Figure 7-8 illustrates a 3D representation of the emissions for a 10 micron particle. Comparing Figure 7-8 to Figure 7-5, we see much heavier emissions escaping to the north side of the car.

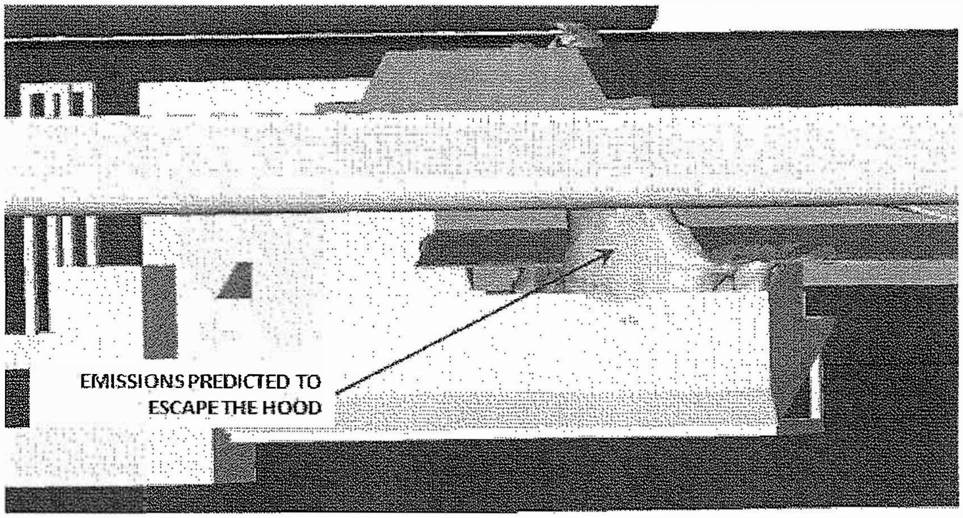

FIGURE 7-8 – COKE PUSHING WITH INTERIOR PLATE REMOVED

As seen above, the model predicts much lower capture efficiency with the interior baffle removed. Given these results, removing the interior baffle will not be considered.

7.6 TURNING VANE ADDED – CAR POSITION No. 3

As seen in Figures 7-5 and 7-6, emissions tend to drift beneath the hood and towards the west. A duct exists on top of the hood with an opening present on the west side. Photo 7-6 shows this opening in the hood.

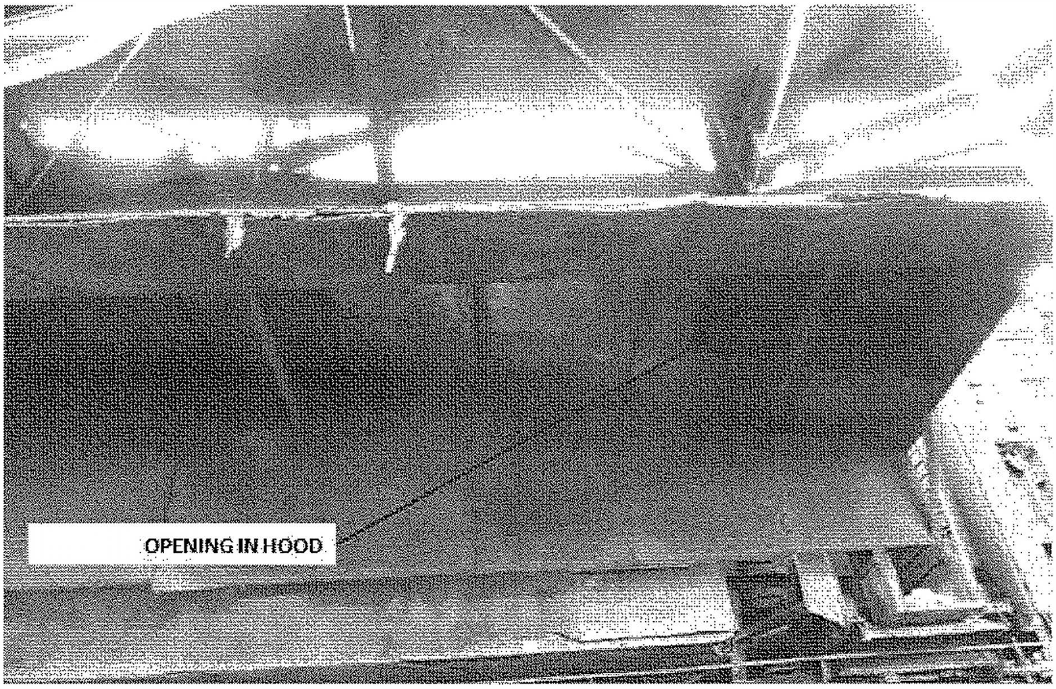

PHOTO 7-6 – TRAVELING HOOD

The intention is to draft emissions which migrate beneath the interior plate back into the emission control system. Figure 7-9 is a section through the center of the duct on top of the hood showing the velocity profile. The model predicts a flow rate of approximately 8,500 acfm through this duct towards the west side of the hood.

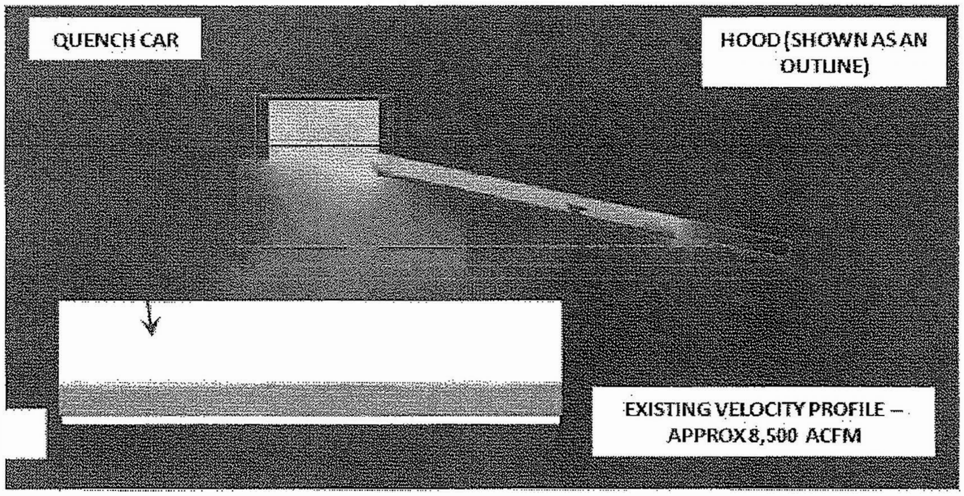

FIGURE 7-9 – VELOCITY PROFILE (SOME ITEMS NOT SHOWN FOR CLARITY)

A series of plates were modeled inside the hood to direct more flow towards the west side of the hood. Figure 7-10 illustrates this concept.

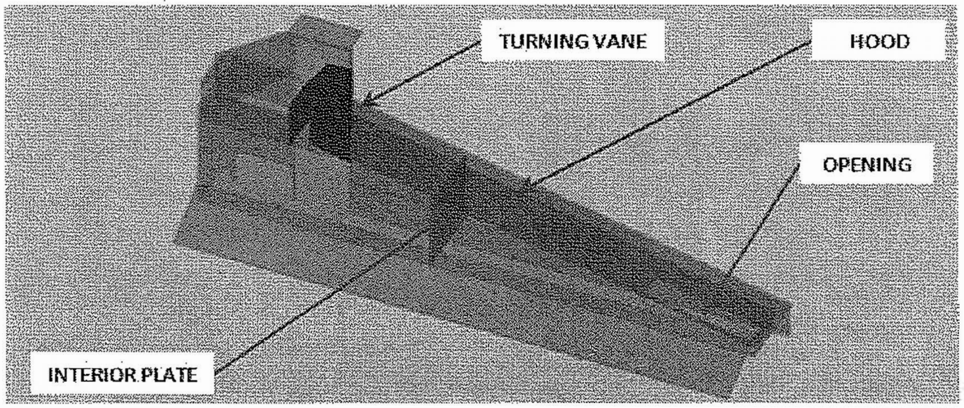

FIGURE 7-10 – INTERIOR TURNING VANES

Once the geometry was updated, the model was run and produced a volume of approximately 18,000 acfm towards the west side of the hood. Figure 7-11 shows the updated velocity profile.

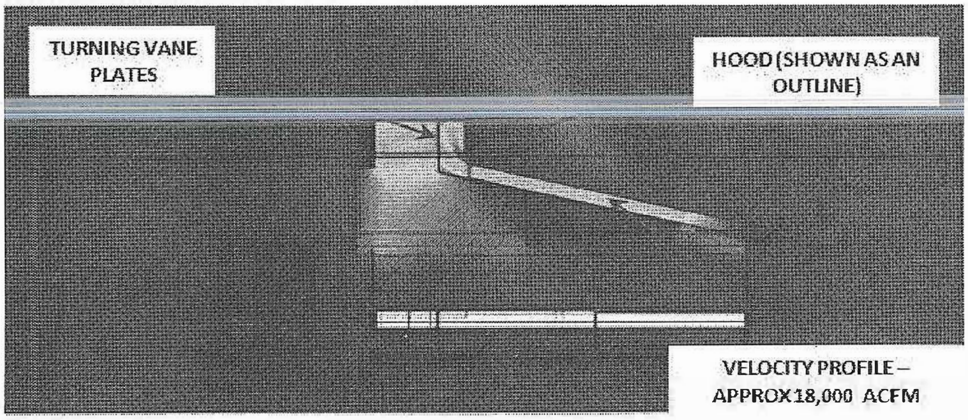

FIGURE 7-11 – VELOCITY PROFILE (SOME ITEMS NOT SHOWN FOR CLARITY)

Figure 7-12 illustrates a 3D representation of the emissions. Comparing Figure 7-12 below to Figure 7-6, we see less emissions from the west side of the hood but more emissions escaping to the north.

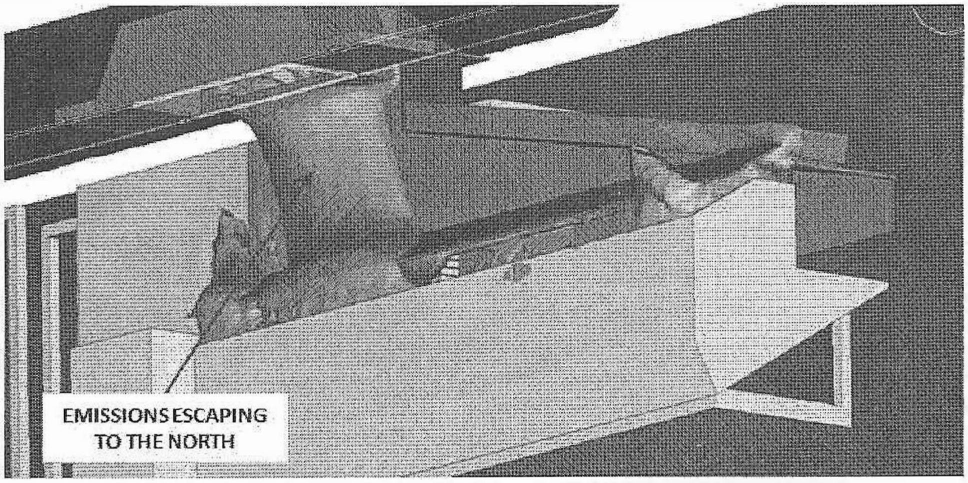

FIGURE 7-12 – COKE PUSHING WITH INTERIOR TURNING VANES

The turning vanes are directing an additional 10,000 acfm towards the west side of the hood. The amount of emissions escaping the west side has been reduced but the amount of emissions escaping from the east has been increased. The addition of the turning vanes has actually decreased the effectiveness of the hood.

7.7 HOOD EXTENSION – CAR POSITION No. 3

Studying the pushing operation, it is apparent that the emissions are escaping towards the north and west side of the hood. This model modifies the hood to minimize the gap between the quench car and the hood to reduce emissions and to allow time for the system to evacuate the emissions. Figure 7-13 shows this concept.

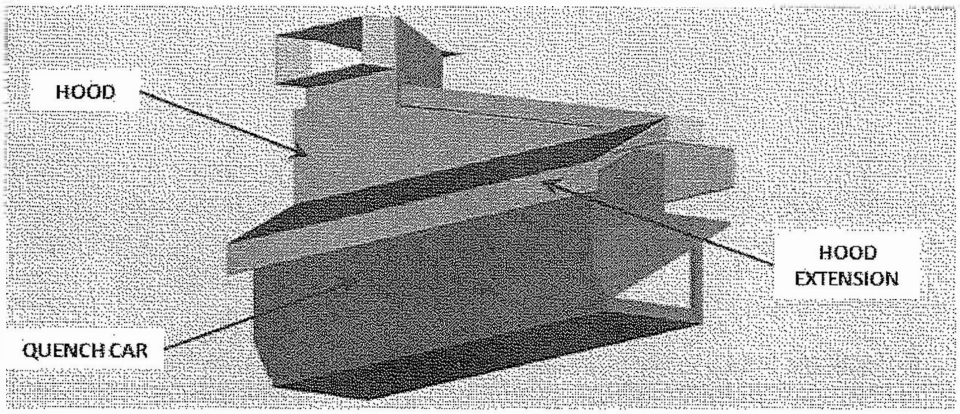

FIGURE 7-13 – HOOD EXTENSION

Figures 7-14 and 7-15 below illustrate a 3D representation of the emissions. Compared to the other modifications considered, adding the hood extensions provides the most significant increase in capture efficiency. This is represented in the figures below. A small portion of emissions can be seen escaping to the east and west but this can be corrected by installing the brushes discussed above along the edges of the hood. This will allow the quench car to move beneath the hood and still maintain a barrier to keep emissions inside the hood.

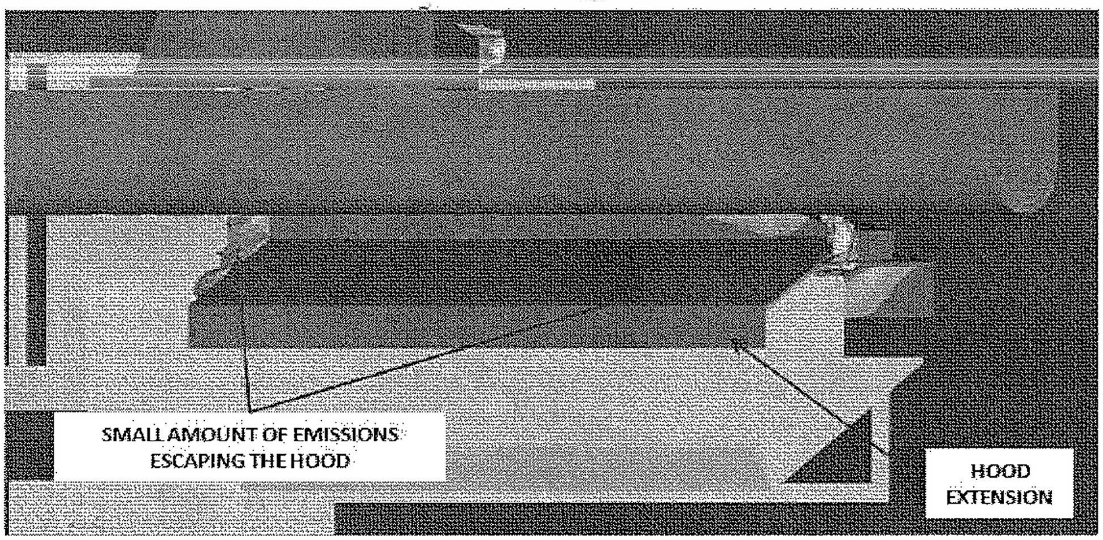

FIGURE 7-14 – COKE PUSHING WITH MODIFIED EXTERIOR PLATES

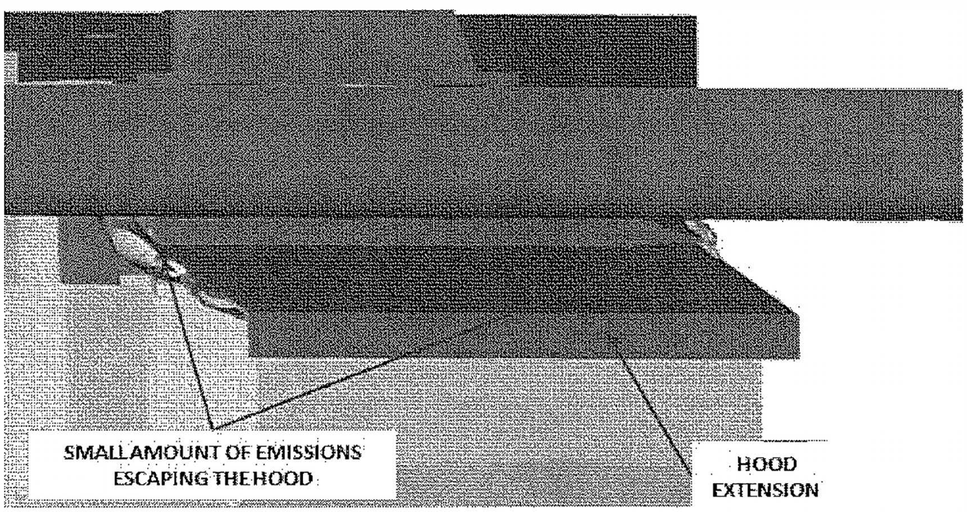

FIGURE 7-15 – COKE PUSHING WITH MODIFIED EXTERIOR PLATES

7.8 NEW HOOD – CAR POSITION No. 3

As discussed previously, modifying the existing hood provides a significant increase in capture efficiency. As seen in all cases, the emissions tend to roll in either the east or west directions and eventually escape the hood. The duct on top of the existing hood attempts to draw air from the west side of the hood but does not perform adequately. As seen in Photo 7-7, the west side of the hood (the right side in the photo) does not provide for any "storage" of the emissions. As the emissions are generated from the coke, they pass beneath the opening in the hood. If the influence of the opening is not sufficient to turn and pull the emissions into the duct, the emissions will escape into the atmosphere, as is the case with the existing hood.

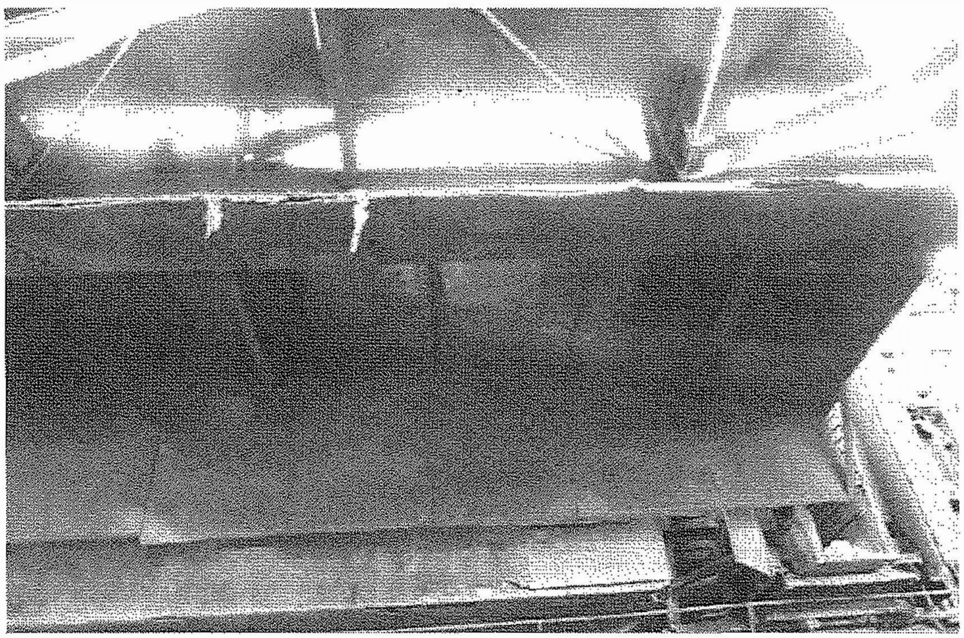

PHOTO 7-7 – TRAVELING HOOD

In this model run, the redesigned hood keeps many of the characteristics of the existing hood except for one feature. The slope of the hood, from east to west, is modified slightly to provide "storage" of the emissions. This extra volume will hold the emissions to provide time for the emission control system to evacuate the hood. Figure 7-16 shows the new hood design.

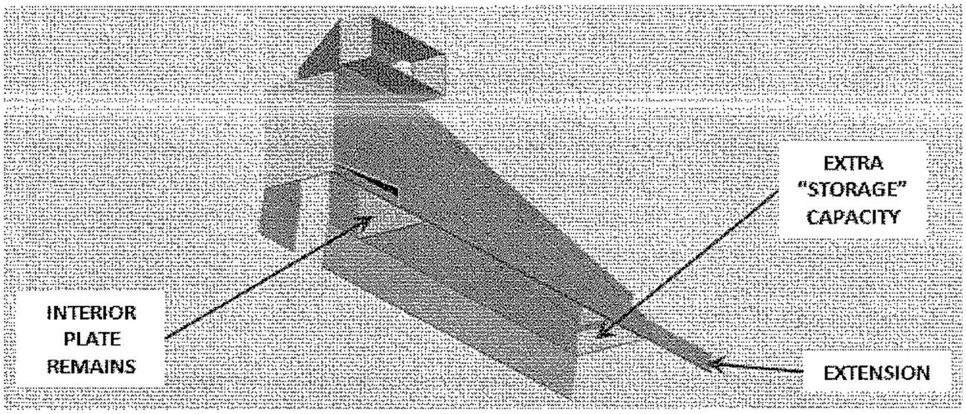

FIGURE 7-16 – PROPOSED HOOD

Figures 7-17 and 7-18 show a 3D representation of the emissions for a 10 micron particle. As seen below, the extra "storage" volume on the west side of the hood does an excellent job in containing the emissions to provide the system time to evacuate the hood. The ventilation volume in the hood duct was increased from approximately 8,500 acfm to approximately 11,500 acfm. A minor amount of emissions can be seen escaping from the east side. As with the hood extension above, this area can be sealed with stainless steel brushes.

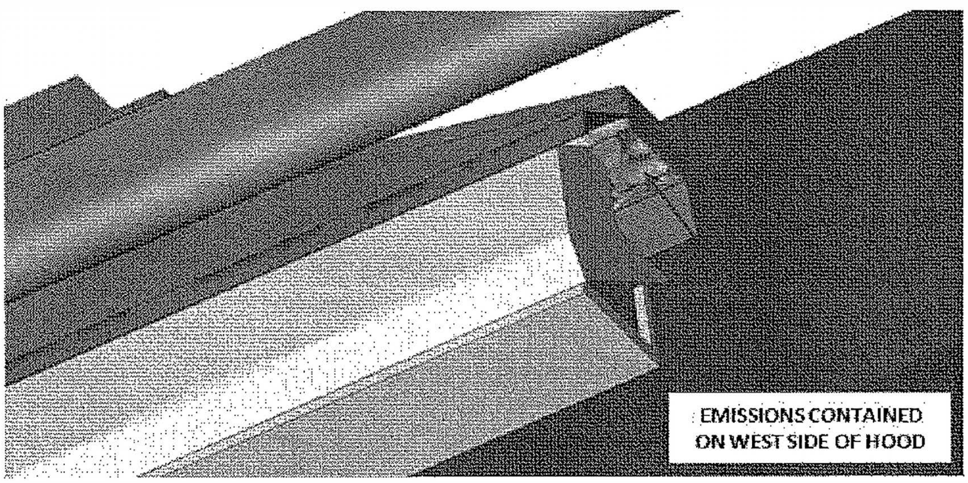

FIGURE 7-17 – COKE PUSHING WITH NEW HOOD

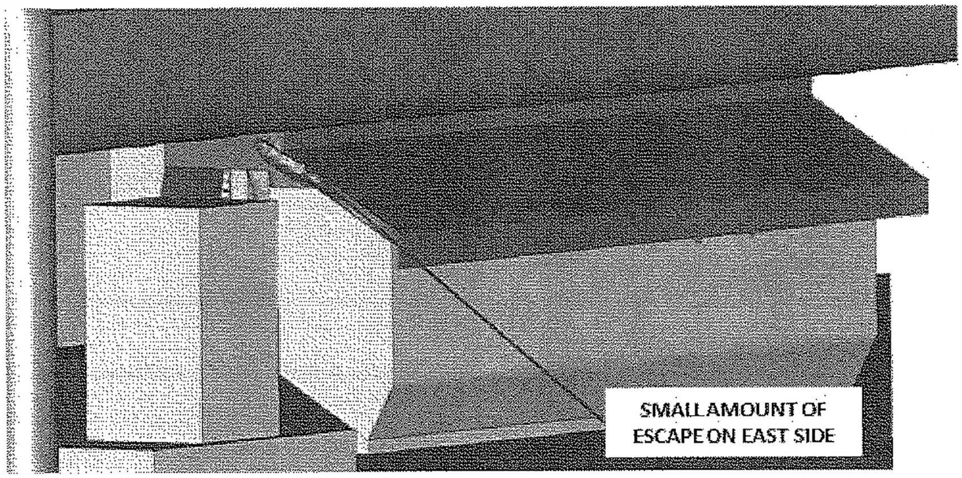

FIGURE 7-18 – COKE PUSHING WITH NEW HOOD

The new hood design presented provides the most significant increase in the capture efficiency. A detailed list of the scenarios and respective capture efficiencies can be found in Section 8.0.

8.0 SUMMARY OF MODEL RESULTS

Table 8-1 summarizes the model run with its respective capture efficiency.

TABLE 8-1 – CAPTURE EFFICIENCY

	SCENARIO	WIND	OVEN	CAR POSITION	CAPTURE EFFICIENCY
1	BASE CASE	FROM NORTH	DOOR No. 40	CAR POSITION No. 1	87.2
2	BASE CASE	FROM NORTH	DOOR NO. 1	CAR POSITION No. 1	86.1
3	BASE CASE	FROM NORTH	DOOR NO. 1	CAR POSITION No. 2	81.2
4	BASE CASE	FROM NORTH	DOOR NO. 1	CAR POSITION No. 3	71.2
5	BASE CASE	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 1	83.9
6	BASE CASE	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 2	80.9
7	BASE CASE	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 3	70.1
8	BASE CASE	FROM EAST	DOOR NO. 40	CAR POSITION No. 1	86.9
9	BASE CASE	FROM EAST	DOOR NO. 40	CAR POSITION No. 2	82.1
10	BASE CASE	FROM EAST	DOOR NO. 40	CAR POSITION No. 3	72.4
	ALTERNATE SCENARIOS				
A1	ADD BRUSHES AROUND COKE GUIDE (S7.4)	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 1	85.1
A2	REMOVE INTERNAL PLATE (S7.5)	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 2	68.0
A3	ADD TURNING VANE (S7.6)	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 3	63.1
A4	HOOD EXTENSION (S7.7)	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 3	84.0
A5	NEW HOOD (S7.8)	FROM NORTH WEST	DOOR NO. 1	CAR POSITION No. 3	88.3

The average base case capture efficiency, that is, accounting for all three car positions at varying wind directions, ranges from 78% to 81%.

The alternate runs, designated as A1, A2...A5, can be directly compared to models 5, 6 or 7 as these models are identical with respect to the oven door, car position and wind direction. For example, alternate run A4 Hood Extension, as found in Section 7.7 in the report, has a capture efficiency of 84%. This model run can be directly compared to model run No. 7 which shows a capture efficiency of 70.1%.